TIME AND CROPS INFLUENCES ON CARABIDS TAXONOMIC AND FUNCTIONAL DIVERSITIES WITHIN A PESTICIDE-FREE AGROFORESTRY CROPPING SYSTEM

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Abstract

Within a pesticide-free agroforestry cropping system, carabids' communities are trapped once over years and, over weeks for one given year in order to test (1) the ageing of the cropping system, (2) the impacts of the presence of different crops and of their related agricultural practices. Main results shown that the carabids communities are different between years but no progressive diversity increase was observed. Conversely, annual climatic conditions showed significant effect on carabids abundance and limited the observation of any longitudinal trend. Then, significant differences between habitats, crops and cropping systems were observed. If diversity between closed and open-habitats was significantly different, no effect was observed between open-habitats despite the presence/absence of specific carabids species in each one. Altogether, results suggest that the SCA0PEST platform is still too young to demonstrate of the ecological connectivity enhancement potential of agroforestry, if exist.

Keywords: SCA0PEST; pesticide-free system; carabids 'communities; NMDS; IPM

Introduction

Very frequently, farmers argue that decision towards adoption of agroforestry systems is supported by the possibility to obtain benefits i.e. ecosystemic services from the system set up. Among others, these benefits concern the potential control of pests by their natural enemies (Fagerholm et al. 2016). By reintroducing linear tree-based plants association around or directly within agricultural parcels, agroforestry reinforce the number and surface of transitional zones in-between landscape units, potentially prolonging one habitat within the adjacent ones. In the same time agroforestry increases the transition zone area all around or within the cultivated parcel, enhancing abiotic edge effect (Murcia 1995) that have in return - (i) direct impact onto the local species abundance and taxonomical diversity and again – (ii) indirect impact on functional diversity by changing species interactions. Among others, ground beetles (Carabidae) answer to the modification of the transitional zones such as habitats fragmentation. In the SCA0PEST pesticide-free agroforestry platform (Grandgirard et al. 2014) part of the work concern carabids; they are surveyed in order to analyze and testify of the potential of the biological control of certain pests.

More precisely, main goals are (i) to identify the taxonomic and functional carabids communities' evolution along time, (ii) to assess the potential effect of crop rotation and associated agricultural practices in order to (iii) produce and share biological pest control references with agroforestry farmers, advisers and students in agroecology.

Materials and methods

Concerning ground beetles, assumptions are several and organized in two groups:

(1) **along time**, we assumed that annual carabids communities would progressively evolve from "open space" community to more rich community with new species or diversification of the carabids functional traits reflecting the ageing of the trees' matrix or of the whole system;

(2) **for one given year**, if carabids communities are relatively unique at the whole parcel scale we assumed that each one of the six experimental parcels composing SCA0PEST should present differences regarding taxonomic and functional diversities reflecting the potential influence of annual crop and practices choices.

To verify the assumptions above, two protocols were conducted within the SCA0PEST platform (see N 49.47458 E 2.06341):

• Protocol n.1: from 2014 up to 2017, in each one of the 6 experimental parcel of SCA0PEST (Figure 1(a)), ground beetles were sampled by pitfall traps at 8 sites (n°1 to 8). Every site was 16 m², at a distance of 4 up to 12m of the tree lines, 20 m apart from each other. It hosted one pitfall trap centered within the site. The first site was 50 m from the forest edge. Trapping period duration was 8 days and started annually approximately on May15th.

• Protocol n.2: in 2017 only, in 3 of the 6 experimental parcels of SCA0PEST (P2-winter wheat, P4- 2-years old alfalfa, P6-field bean), at sites n°2, 4 and 6 (respectively at 50, 70 and 90m from the forest edge), pitfall traps were 3, at 1m apart from each other, respecting a triangle shape (Figure 1(b)). Close to the SCA0PEST platform, 3 groups of 3 pitfall traps were positioned within (a) the contiguous 70 years-old forest "Fo", (b) within an 8-years old forestry control "FC" located within the parcel at 35m from the SCA0PEST platform and hosting a high density (600m^{-2}) of the same agroforestry trees species, (c) within the non-agroforestry reference cropping system "RCS"; respecting the 50/70/90m distance range and the 1m triangle shape. Ground beetles were sampled from May 15th up to mid-July, every 10 days.

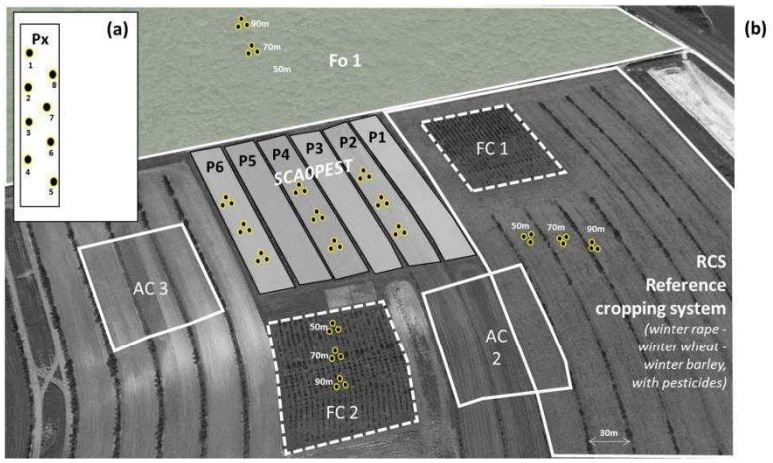

Figure 1: Map of the different conditions present within or around the SCA0PEST platform; (a) pitfall traps position at 8 sites per experimental parcel from 2014 to 2017- protocol n.1; (b) triangular pitfall traps positioning in 2017 - protocol n.2 (AC= agricultural control meaning grassy strips without trees and conventional cropping system; FC= forest control meaning uncultivated area with trees at 600ha^{-1} high density; Fo= Forest meaning 70 years-old forest; RCS= reference cropping system meaning grassy strips with trees and conventional cropping system).

All carabids caught were identified to species using standard keys (Roger at al. 2013). Functional traits were selected a priori and were related to morphology (individual length), reproduction (reproduction period), dispersal (wing morphology) and the resource use (diet). Moreover, Shannon-Wiener and Simpson α-diversity index were performed (Magura 2017). Statistical analyses were performed using R. Non parametric Kruskal-Wallis, Friedman and Mann-Whitney tests were performed (p-value<0.05) and communities were described using

NMDS; community resemblance were tested using ANOSIM and most influential ground beetles species were identified using SIMPER in Past 2.17 (Hammer et al. 2001).

Results

Over the 4 first years of the experimentation, 886 carabids and 29 different species were trapped. Most of them were trapped in 2015 (41%) then in 2017 (31%); only 9% were trapped in 2015 due to heavily rainy spring (results not shown). In the same time, we observed large differences of the specific abundance between experimental parcels suggesting that crops (and related agricultural practices) at a given year would partly condition the ground beetles assemblages. More precisely, statistical tests showed that carabids significantly prefer cereals and rapeseed or again field bean than alfalfa (results not shown). Even if true, the year effect remained higher than the crop effect. Because of this first results, carabids' assemblages were studied independently every year.

For instance, *Amara similata* and *Poecilus cupreus* were related to rapeseed when *Pseudophonus rufipes* was mainly found in field bean and alfalfa. *Harpalus affinis* was related to pesticide-free wheat when *Anchomenus dorsalis* was related to the reference one. In the other hand, *Brachinus sclopeta*, *Notiophilus quadripunctus* or *Demetrias atricapillus* were found in the SCA0PEST wheat where lines of trees and grass strips are present and where they can alternate between habitats, within the transition zone. Whereas they were not found in the reference wheat located in the agricultural control i.e. without lines of trees. Concerning functional traits, the number of generalist species was higher in agricultural control (open-habitat as RCS and SCA0PEST) and forestry "FC" control. Conversely, predatory ground beetles were mainly found in the forest "Fo" habitat.

Assemblages were then analyzed through NMDS. In 2014, supplementary ANOSIM (r=0.54; p-value=0.001) showed that carabids assemblage were different between experimental parcels i.e. between crops and related agricultural practices. Then, the SIMPER function identified major species those explaining this assemblage's differences: when *Pterostichus melanarius* is frequently present in cereals, *Nebria salina* is generally trapped in alfalfa and *Poecilus cupreus* was more present in field bean. However these results were not constant over years as crops are changing according to the crop rotation in place and as some species seemed strongly related to some crops and crops conditions e.g. *Amara sp.* in rapeseed or *Ophonus azureus* in alfalfa. This result was also due to the early apparition of new carabids' species such as *Amara aulica* or *Badister sodali*. Over the 2014-17 period, results showed that the carabids' assemblage tend to become uniform as the ANOSIM R test was decreasing (R=0.44, p-value =0.001 in 2015; R=0.32, p-value =0.001 in 2017).

From protocol n.2, in 2017, 2185 carabids were trapped. Preliminary statistics showed that the distance to the forest edge effect was not significant, whatever the sampling date. Mean daily catches at the three distances (50, 70 and 90m) were then summed and NMDS was mobilized to describe the habitat effect. ANOSIM and SIMPER were then performed: forest's assemblage (Fo) is significantly different from others (RCS, FC and SCA0PEST's assemblages). These habitats have very closed communities but few supplementary carabids species were sampled in very specific cropping conditions (Figure 2) and made significant the multivariate tests performed.

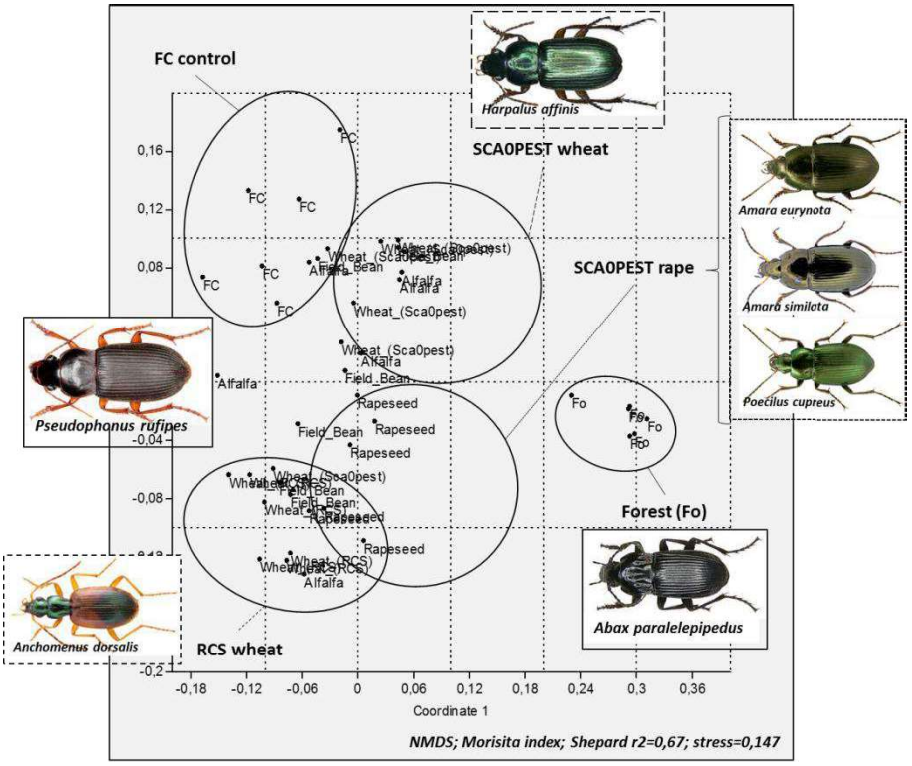

Figure 2: NMDS results of the mean daily catches per habitat in 2017 (carabids.day^{-1}) over the sampling period.

Discussion

If the communities of Carabids appeared significantly different in some extreme conditions met within the SCA0PEST landscape, they stayed relatively closed from each other's because of the omnipresence of five carabids species in each modalities. However, communities of less perturbed habitats such as forest or again forestry control appeared more stable over time. At the opposite, in open-habitats such as agricultural control, some species appeared early in spring and disappeared before summer time, making the communities less stable. Regarding functional diversity, it also appeared different between closed and open-habitats. Moreover if crops and associated agricultural practices have non negligible impact, results showed that rainfall and temperature conditions were major determinant of the carabids assemblages caught. These first results could be as positive as carabids communities has been enriched of new species adapted to transition zone and having corresponding functional life traits. It could be the first signs of the installation of a biological control potential in SCA0PEST. However, SCA0PEST is still very young and the observed trends remain insufficient to conclude of the potential ecosystemic services carabids could provide. In the literature most of the time effects on assemblages are rapidly observed as forest carabids could appear during the 1st year, but when we speak about functional communities and eco-systemic services (ES) time needed generally increase up to 10-15 years (soil fertility and fauna, integrated pests management) or even more depending of the ES considered (water quality, CO_2 sequestration …).

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